International Journal of Architecture and Urbanism Vol. 04, No. 01, 2020 | 30 – 43

Study of Interior Materials as Passive Fire Protection in Karaoke Building (Case Study: Masterpiece Signature Family KTV Medan)

Saras Ayu Faradita1*, Vinky Rahman1

[1]*ArchitectureDepartment, Faculty of Engineering, Universitas Sumatera Utara,Medan, Indonesia*

Abstract The fire incident in karaoke buildings in Indonesia which claimed many lives has occurred several times. According to the National Academy of Science US, the smoke toxins that come out of the fire disaster cause 50-80% of deaths. Refers to the data, it is necessary to check further about the building material response to fire during a fire incident. Masterpiece Signature Karaoke is a karaoke building that classified as large and magnificent in the city of Medan which has various material so that it is necessary to study the interior material as passive fire protection. The purpose is to find out how to assess the reliability of fire passive protection regard to the interior materials and recommendations or descriptions of right interior material planning using the Analytical Hierarchy Process (AHP). This method is efficacious to solve the problem of reliability in using interior materials as passive fire protection in Masterpiece Signature Family KTV Medan building with the results of an Adequate Level of reliability. Then, design recommendations were given for the use of interior materials in karaoke building to improve the reliability results to be better.The results are useful as information for other researchers and karaoke buildings regarding passive fire protection systems at the Masterpiece Signature Family KTV Medan.

Keyword:fire, interior,karaoke, material,protection,system

1. Introduction

Fire is an event or occurrence of uncontrolled fire which can endanger the safety of life or property which are caused by various factors such as technical factors, human factors, and natural factors.In the Karaoke Building, the building functions and activities are unique and specific, so a transparent and standardized fire protection system is needed. It concerns the existence of sources of fire, the level of difficulty in evacuating occupants of buildings, and the use of materials that are also prone to burning. Characteristics of karaoke buildings with the use of acoustic materials such as wall coating material and the floor is a combustible material so that in the event of a fire will cause the fire to develop rapidly and have a high heat release value. Also, toxic reactions to material against fire and smoke during a fire are quite dangerous for humans.

*Corresponding author at:Architecture Department, Faculty of Engineering, Universitas Sumatera Utara, Perpustakaan street, J07Building, Medan 20155, Indonesi a

E-mail address: sarasayufrdt@gmail.com

Based on data from the Ministry of the Interior, Indonesia, in 2011, as many as 16,500 fires occurred in Indonesia. The fires of karaoke buildings in several cities in Indonesia also occurred several times, some of which were karaoke fires in the city of Medan where a flame claimed 20 deaths even though it occurred inside a building with only four floors (www.news.okezone.com), and a fire a three-story karaoke building in the city of Manado in 2015 which killed 12 people (www.regional.kompas.com). A data also quoted from the US National Academy of Sciences (1986) notes that the smoke toxins that come out of the fire cause 50% to 80% of deaths due to fires. Therefore, building interior materials need to be explored further about the reactivity of the material to fire and smoke during a fire.

When a fire occurs in a karaoke building as an emergency, things that are the main priority to be saved are the lives of users or visitors, so that the fire protection system is needed, and the most prominent karaoke building is the interior material as a passive fire protection system considering the variety of building interior materials karaoke. Therefore, this study examines the use of interior materials as a passive fire protection system in the Karaoke Building.

2. Literature Review

According to David A. Cooling and NFPA, fire is an effusive flame where there are three elements make up the oxidation reaction, which are fuel, oxygen, and heat sources as causes material and moral losses.[3]According to the Instruction of the Minister of Manpower No: Ins. 11/M/BW/1997, fire passive protection system is a workplace design technique to control or inhibit the spread of fire, smoke, heat, and gas by installing fire-retardant walls, closing any openings with fire-resistant or certain mechanization media. So it can be concluded that the passive protection system is a supporting material that is inhibiting the firing process. Passive protection will burn its room, and blocked the fire from spreading to other areas so that it can protect the occupants of the building from evacuating safely.

According to the Decree of the Minister of Public Works No: 10/KPTS/2000, concerning the technical requirements for safeguarding fire hazards in buildings and the environment, the following are the provisions of the building material characteristic to fire. [4]Building materials and building structure components in each class of buildings (grades 2, 3, 5, 6, 7, 8, or 9) should be able to withstand fire spreading, and control the occurrence of smoke. Therefore, the condition of the room inside the building remains safe for residents while carrying out an evacuation.The performance of building materials against fire by the Decree of the Minister of Public Works No. 10/KPTS/2000.

Fuel Characteristic of Interior Materials

The following table is about material resistance to the fire according to SNI-03-1736-2000 (Table 1) and textile materials resistance to the fire, which is very needed in this study about karaoke building(Table 2).

Table 1. Materials Resistance to Fire

Material	Characteristic	Fire Resistance
Steel	Change its shape by the influence of heat. Can be influenced by the type of mixture forming.	Chromium (Cr), Molybdenum (Mo), Nickel (Ni), or Vanadium (V), produce steel that has a higher resistance to heat.
Concrete	Fire resistance building materials.	Fire resistance depends on the additional material used and whether or not there is a steel reinforcement.
Glass	No flame building materials.	Not a fire-resistant material because glass allows heat radiation translucent. Glass is very reactive to changes in heat stress, which results in a quite rapid glass fire.
Wood	Wood burning isoxidation of its original elements, which are H20 and CO2 with O2.	Fire-resistant materials in case it does not expose directly to fire.
Synthetic Material	Synthetic material is a combustible and flammable material.	When it burns, synthetic materials cause liquid drops that are difficult to extinguish. Which then produces thick smoke and releases toxic gases.

(*Source: SNI-03-1736-2000*)

Table 2. Textile Materials Resistance to Fire

Textile Material	Flame Characteristic	Smokey Characteristic
Naturals	Burn easily. High flame.	A small amount of smoke.
Cotton	Flammable. Keep burning while extinguishing.	Smoke is white gray.
Hemp	Flame characteristic as same as cotton.	Smoke is white gray.
Linen	The flame character is a bit like cotton, but it is harder to ignite, and the spreading of the fire is very slow.	Smoke iswhite gray.
Silk	Flammable burns easily, and the thicker the textile, the slower it burns.	Dark gray smoke
Wool	The fire is slightly flammable, but the fire is spreading slowly like silk.	Smoke is more concentrated than silk
Rayon	Burned more slowly than cotton. Steady flame.	Dark gray smoke
Synthetics	High flame and melt if it burns.	Smoke is concentrated and thick
Acetate	High flame spread quickly.	Solid and thick smoke
Acrylic	Fire spreads quickly. Will flame if the fire has long been in the textile.	Gray smoke is a bit dark
Nylon	Melt then burn. Fire spreads slowly.	White smoke
Polyester	Melt and burn at the same time	Deep black smoke

Toxicity of Interior Materialsalso becomes a rating factor. Approximately inhalation of smoke from burns causes 50 - 80% of deaths during a fire. According to the NFPA 92A in 1996, smoke is gas as stable and liquid particles that flew as a result of the combustion process along with the air mixed in it. The production of smoke depends on two things, namely the size of the fire and the height of the ceiling. The smaller the height of the space above the flame causes the stack of a smoke layer to thicken faster, the more open space above the fire, the smoke will decrease. The type of smoke produced is different for each fire, as well as the toxic gases produced by fire, depending on the material or material burned (Table 3).

Table 3. Toxic Gas from Combustion

Material	Toxic Gas
All combustible materials containing carbon	CO and CO_2
Celluloid, polyurethane	Nitrogen Oxide (NO)
Wool, silk, leather, plastic contains nitrogen	Hydrogen Cyanide
Rubber, Thiokol	Sulfur Dioxide $(SO)_2$
Polyvinyl chloride, plastic retardant, plastic contains flour	Halogen Acid (HCl, HBr, HF, and phosgene)
Melamine, nylon, resin, urea-formaldehyde	Ammonia (NH_3)
Polystyrene	Benzene (C_6H_6)
Phenol formaldehyde, nylon, polyester resin	Aldehyde
Plastic retardant	Antimony Compound (Sb)
Polyurethane Foam	Isocyanate
Wood, Paper	Acrolein (C_3H_4O)

Toxic and dangerous gas that is most often produced by fire is carbon monoxide (CO) gas. The effect of inhaling carbon monoxide gas in CO concentrations, in general, is 1500 is Headache in 15 minutes, fainting in 30 minutes, dying within 1 hour. Inhaling smoke from any gas fire has a harmful effect, but the most dangerous is carbon monoxide gas, then the next one that has a moderate risk of danger is CO2, HCn, COCl2, and HCl, and the least risk of smoke are other poison gases.

The other rating factor is building category.Building according to the Minister of Public Works Number 45 / PRT / M / 2007 is a physical form of the results of construction work that integrates with the place and position, partially or entirely above and know in the soil or water. It serves as a place for people to do activities, both for shelter or residence, religious activities, business activities, social activities, cultural activities, and special activities.

In this case, there is a karaoke building. The karaoke building is an entertainment place of singing which is accompanied by an orchestra without vocal sound and with other supporting facilities. With its function as a place for visitors who want to unwind from their routines, in general, the

karaoke building is specifically designed to take into account the artistic factors in interior design arrangement and also consider the acoustic factors of space, area/dimensions of the room and also ergonomic factors that provide comfort for karaoke visitors.

The method of this study is AHP. AHP (Analytical Hierarchy Process) is a decision support model developed by Thomas L. Saaty. This decision support model will describe complex multi-factor problems into a hierarchy. Hierarchy explains effectively complex problems into groups which are then arranged into a hierarchical form so that the problems will appear more structured and systematic.[1]

3. Methodology

This study discusses the study of interior materials as passive fire protection in Masterpiece Signature Family KTV Medan as a karaoke building, so the type of research used is descriptive, comparative, qualitative and quantitative research, where the data obtained from theoretical studies and observations/surveys of buildings This will be compiled and analyzed to get the conclusion from this research. The final result of this study is the right interior materials recommendation.

Then the next step is to determine each variable and sub-variable of the research on the interior materials to find out the existing conditions in each case study of the hospital building, can be seen in table 4.

Table 4. Variables and Sub - Research Variables

Serial Number	Code	Sub Variable
		A. Material Characteristic
1	A1	Material Resistance to Fire
2	A2	Toxicity
3	A3	The Rapid Spread of Fire
		B. Room Types
1	B1	Karaoke Room
2	B2	Evacuation Corridor
3	B3	Stairs
4	B4	Lobby
		C. Room Elements
1	C1	Wall Surface
2	C2	Ceiling Surface
3	C3	Floor Surface
4	C4	Furniture

To determine the weight and reliability value of interior materials as passive fire protection in Karaoke Buildings can be seen in the following stages.

First of all, we ordering of Interests in reach Sub – Variable. All sub-variables are given criteria of importanceto rank them, the criteria used are to see how significant one sub-variable is to another sub-variable in a passive fire protection system on the interior materials. After each sub-variable bring in value, the next step is to find the weight of each sub-variable by creating a matrix. In this matrix calculation, researchers use Ms.'s application. Office Excel with nine references of importance weight as follows based on Saaty's theory (table 5)[1].

Table 5. Scale table of sub-variables of interest Ms. AHP Method Office Excel

Value	Information
1	A is equally essential with criterion B
3	A is slightly more important than B
5	A is more important than B
7	A is very clearly more essential than B
9	A is absolutely more critical than B
2, 4, 6, 8	When in doubt between two adjacent values

(Source: Saaty, 1998)

To provide the value of each variable based on the availability of these variables in the object of research. The following criteria for evaluating the availability of variables are as follows (Table 6).

Table 6. Reliability Interior Materials Components.

Value	Explanation
The Scale of Availability Assessment of Material Resistance to Fire Variables	
1	Material components are not fire-resistant at all
2	A small part of the interior material components are fire-resistant
3	Most components are fire-resistant
4	All components used are fire-resistant
The Scale of Availability Assessment of Toxicity Variables	
1	Components of the material used are heavy poisons when exposed to fire
2	A small part of the interior material component is moderate to poison when exposed to fire
3	Most refractory components are mild toxins when exposed to fire
4	All components used are not toxic when exposed to fire
The Scale of Availability Assessment of the Rapid Spread of Fire	
1	Components of the material used spread the fire very quickly
2	A small part of interior material components spread the fire quickly
3	Most components slow to spread fire
4	All components used do not spread fire

The final stage is to determine the rating scale of a passive fire protection system based on the following table (Table 7).

Table7. Reliability Value

Value	Explanation
1 < x ≤ 1.6	Bad
1.7 < x ≤ 2.2	Deficient
2.2 < x ≤ 2.8	Sufficient
2.8 < x ≤ 3.4	Good
3.4 < x ≤ 4.0	Excellent

4. Result and Discussion

Research Location Data: Masterpiece Signature Family KTV Medan

The area that became the research site was a karaoke building located on Jalan Multatuli No. 30 ABC, Medan. Here is a picture of the location of this research location (Figure 1).

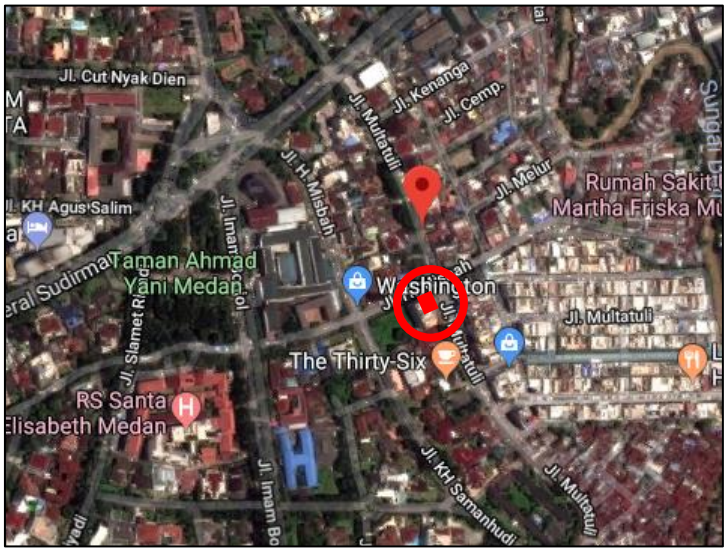

Figure 1. Research site maps

(*Source : https://earth.google.com*)

The Masterpiece Medan karaoke building established since 2010. However, in 2010, it was still named Inul Vizta, then changed its name to Bona Vista, until in 2018 the name was changed to Masterpiece. This building is a four-story building which includes karaoke rooms, lobbies, evacuation corridors, and stairs. Here is the Masterpiece Plan for Karaoke Medan (Figure 2).

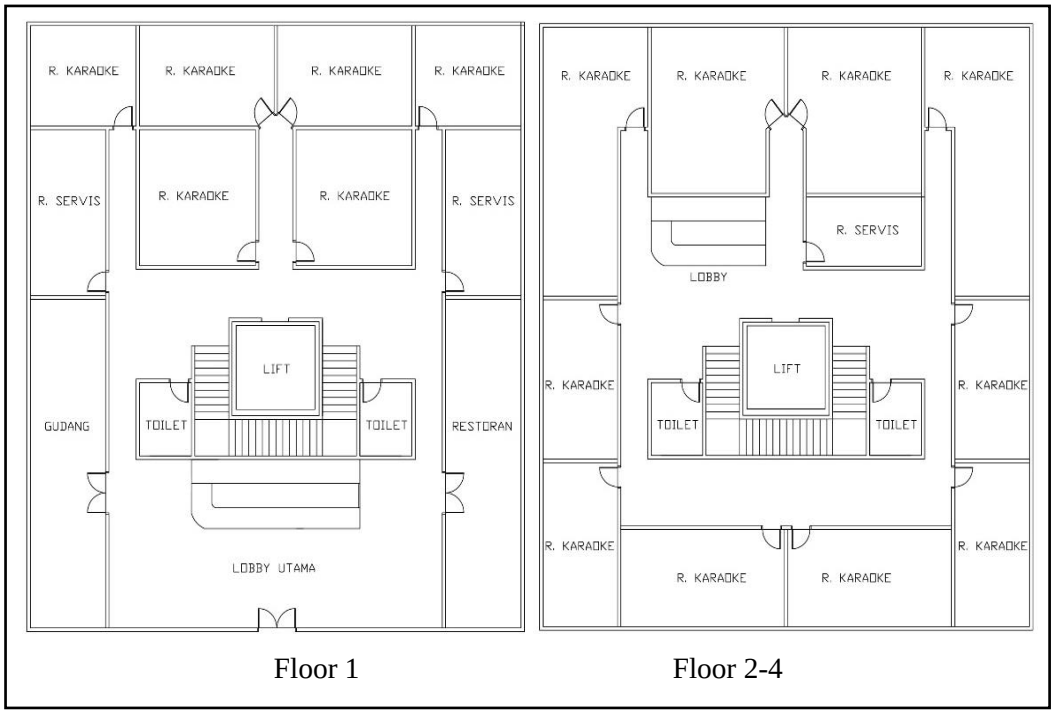

Figure 2. Masterpiece Signature Family KTV Medan Plan

The following are the results of a survey of conditions of interior materials of Masterpiece Signature Family KTV Medan (Figure 3).

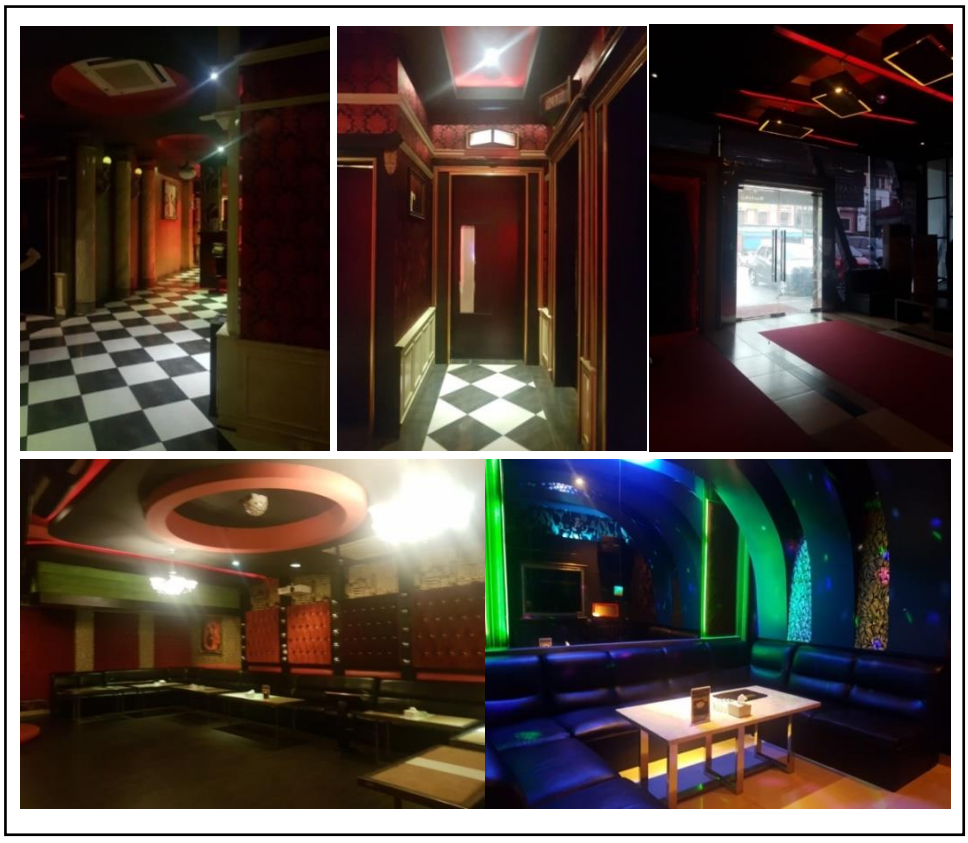

Figure 3. Masterpiece Signature Family KTV Medan Interior

Reliability data processing result of interior materials as passive fire protection usesAHPmethod with application Office Excel. As for the results of processing the AHP Method with Ms. Application Office Excel based on the sequence of work steps is as follows.The first step is to sort each variable and sub-variable. The following is the order of importance to get the results of the rating scale (Table 8).

Table 8. Table of Interest Sequences for each Variable and Sub Variable.

Serial Number	Code	Sub Variable
A. Material Characteristic		
1	A1	Material Resistance to Fire
2	A2	Toxicity
3	A3	The Rapid Spread of Fire
B. Room Types		
1	B1	Karaoke Room
2	B2	Evacuation Corridor
3	B3	Stairs
4	B4	Lobby
C. Room Elements		
1	C1	Wall Surface
2	C2	Ceiling Surface
3	C3	Floor Surface
4	C4	Furniture

Thefollowing stages calculate the weight of each variable to get the percentage of each variable.To determine the valuation of the importance of each variable or sub-variable assisted by reference to filling in a matrix that is appropriate to the existing conditions of the karaoke building interior materials during the survey can be seen in Table 9[1].

Table 9. Variable and Sub-Variable Interest Scale

Value	Information
1	A is equally important with criterion B
3	A is slightly more important than B
5	A is more important than B
7	A is very clearly more important than B
9	A is absolutely more important than B
2,4,6,8	When in doubt between two adjacent values

(Source: Saaty, 1998)

After determining the valuation of interests in the variables, the next step is by examining the initial comparison in table 10, 11, and 12.

Table 10. Calculation of the initial matrix of Variable interests A

	A1	**A2**	**A3**
A1	1.00	3.00	1.00
A2	0.33	1.00	3.00
A3	1.00	0.33	1.00
	2.33	4.33	5.00

Table 11. Calculation of the initial matrix of Variable interests B

	B1	**B2**	**B3**	**B4**
B1	1.00	1.00	2.00	1.00
B2	1.00	1.00	1.00	2.00
B3	0.50	1.00	1.00	2.00
B4	1.00	0.33	0.50	1.00
	3.50	3.50	4.50	6.00

Table 12. Calculation of the initial matrix of Variable interests C

	C1	**C2**	**C3**	**C4**
C1	1.00	3.00	2.00	1.00
C2	0.33	1.00	3.00	5.00
C3	0.50	0.33	1.00	3.00
C4	1.00	0.20	0.33	1.00
	2.83	4.53	6.33	10.00

After calculating the initial matrix, which gives the value of each variable's importance, then normalize of the comparison.

After calculating the initial matrix and the normalization matrix comparing the interests of each variable, then calculating the weight of each sub-variable to get the weight percent of the sub-variables that have been sorted out, which are the following table (table 13, 14, and 15).

Table 13. Initial comparison matrix and sub-variable normalization of each sub-variable of variable A

	A1	A2	A3	Jumlah secara baris	Periority Vektor	Bobot	Bobot Akhir
A1	0.43	0.69	0.20	1.32	0.44	1.65	0.46
A2	0.14	0.23	0.60	0.97	0.32	1.18	0.33
A3	0.43	0.08	0.20	0.71	0.24	0.78	0.22
	1.00	1.00	1.00	3.00		3.61	1.00

Table 14. Initial comparison matrix and sub-variable normalization of each sub-variable of variable B

	B1	B2	B3	B4	Jumlah secara baris	Periority Vektor	Bobot	Bobot Akhir
B1	0.29	0.29	0.44	0.17	1.18	0.30	1.25	0.30
B2	0.29	0.29	0.22	0.33	1.13	0.28	1.18	0.28
B3	0.14	0.29	0.22	0.33	0.98	0.25	1.03	0.25
B4	0.29	0.14	0.11	0.17	0.71	0.18	0.74	0.18
	1.00	1.00	1.00	1.00	4.00		4.19	1.00

Table 15. Initial comparison matrix and sub-variable normalization of each sub-variable of variable C

	C1	C2	C3	C4	Jumlah secara baris	Periority Vektor	Bobot	Bobot Akhir
C1	0.35	0.66	0.32	0.10	1.43	0.36	1.83	0.37
C2	0.12	0.22	0.47	0.50	1.31	0.33	1.67	0.33
C3	0.18	0.07	0.16	0.30	0.71	0.18	0.88	0.18
C4	0.35	0.04	0.05	0.10	0.55	0.14	0.62	0.12
	1.00	1.00	1.00	1.00	4.00		5.00	1.00

Data Processing to determine Reliability Value

So the last stage is processing data from the results of the percent weight of sub-variables to determine the reliability value of each case study of the Masterpiece Signature family KTV Medan karaoke building (Table 16).

Table 16. Masterpiece Signature family KTV Medan Data Processing

Serial Number	A. Material Characteristic	B. Room Types	C. Room Elements	Weight A	Weight B	Weight C	Weight	Total Weighting	Last Weighting	The Value of Availability	Total	Final Total	Value
A1	Material Resistence to Fire **WEIGHT: 46%**	Karaoke Room	Wall Surface	1.65	1.25	1.83	1.58	21.07	0.07	1	0.07	2.67	1.22
			Ceiling Surface			1.67	1.52		0.07	4	0.29		
			Floor Surface			0.88	1.26		0.06	2	0.12		
			Furniture			0.62	1.17		0.06	2	0.11		
		Evacuation Corridor	Wall Surface		1.18	1.83	1.55		0.07	3	0.22		
			Ceiling Surface			1.67	1.50		0.07	3	0.21		
			Floor Surface			0.88	1.24		0.06	3	0.18		
			Furniture			0.62	1.15		0.05	4	0.22		
		Stairs	Wall Surface		1.03	1.83	1.50		0.07	2	0.14		
			Ceiling Surface			1.67	1.45		0.07	3	0.21		
			Floor Surface			0.88	1.19		0.06	2	0.11		
			Furniture			0.62	1.10		0.05	4	0.21		
		Lobby	Wall Surface		0.74	1.83	1.41		0.07	2	0.13		
			Ceiling Surface			1.67	1.35		0.06	3	0.19		
			Floor Surface			0.88	1.09		0.05	3	0.16		
			Furniture			0.62	1.00		0.05	2	0.10		
A2	Toxicity **WEIGHT: 33%**	Karaoke Room	Wall Surface	1.18	1.25	1.83	1.42	18.56	0.08	1	0.08	2.64	0.86
			Ceiling Surface			1.67	1.37		0.07	3	0.22		
			Floor Surface			0.88	1.10		0.06	3	0.18		
			Furniture			0.62	1.02		0.05	3	0.16		
		Evacuation Corridor	Wall Surface		1.18	1.83	1.40		0.08	2	0.15		
			Ceiling Surface			1.67	1.34		0.07	2	0.14		
			Floor Surface			0.88	1.08		0.06	4	0.23		
			Furniture			0.62	0.99		0.05	4	0.21		
		Stairs	Wall Surface		1.03	1.83	1.35		0.07	3	0.22		
			Ceiling Surface			1.67	1.29		0.07	2	0.14		
			Floor Surface			0.88	1.03		0.06	4	0.22		
			Furniture			0.62	0.94		0.05	4	0.20		
		Lobby	Wall Surface		0.74	1.83	1.25		0.07	3	0.20		
			Ceiling Surface			1.67	1.20		0.06	2	0.13		
			Floor Surface			0.88	0.93		0.05	2	0.10		
			Furniture			0.62	0.85		0.05	1	0.05		
A3	The Rapid Spread of Fire **WEIGHT: 22%**	Karaoke Room	Wall Surface	0.78	1.25	1.83	1.29	16.43	0.08	2	0.16	3.08	0.67
			Ceiling Surface			1.67	1.23		0.08	4	0.30		
			Floor Surface			0.88	0.97		0.06	3	0.18		
			Furniture			0.62	0.88		0.05	2	0.11		
		Evacuation Corridor	Wall Surface		1.18	1.83	1.26		0.08	4	0.31		
			Ceiling Surface			1.67	1.21		0.07	4	0.29		
			Floor Surface			0.88	0.95		0.06	3	0.17		
			Furniture			0.62	0.86		0.05	4	0.21		
		Stairs	Wall Surface		1.03	1.83	1.21		0.07	2	0.15		
			Ceiling Surface			1.67	1.16		0.07	4	0.28		
			Floor Surface			0.88	0.90		0.05	3	0.16		
			Furniture			0.62	0.81		0.05	4	0.20		
		Lobby	Wall Surface		0.74	1.83	1.12		0.07	2	0.14		
			Ceiling Surface			1.67	1.06		0.06	3	0.19		
			Floor Surface			0.88	0.80		0.05	3	0.15		
			Furniture			0.62	0.71		0.04	2	0.09		
Value of Reliability													**2.75**

From the results of the above calculations, then compared with the value of the comparison scale (table 17).

Table 17. Value of Reliability Assessment.

Value	Explanation
$1 < x \leq 1.6$	Bad
$1.7 < x \leq 2.2$	Deficient
$2.2 < x \leq 2.8$	Sufficient
$2.8 < x \leq 3.4$	Good
$3.4 < x \leq 4.0$	Excellent

5. Conclusion

This study uses the Analytical Hierarchy Process (AHP) method, which is beneficial to solve problems in decision support systems that are very easy and appropriate for users of other academic communities.Recommendations for improvement in improving the reliability of fire stairs : (a) Some sub-variables do not meet the requirements. Therefore, researchers made the design recommendation of the interior materials, and the result ismaterial resistance to firefrom **2,67 (sufficient)** to **3,45 (good)**, Toxicity: from **2,64 (sufficient)** to **3,16 (good)**, The Rapid Spread of Fire: from **3,08 (good)** to **3,66 (excellent)**. From the results of the analysis on the interior materials by using the Analytical Hierarchy Process (AHP) method, the design of the interior materials, so that the reliability level of the material interiors is much better, i.e., from 2.75 to 3.60.(b) It means that the material replacement following the recommendations has made the reliability value of the use of interior material recommendations as passive fire protection in karaoke buildings increased, and has been able to meet the points and regulations of the requirements regarding passive fire protection. Decree of the Minister of State for Public Works of the Republic of Indonesia No.10/KPTS/2000 for type 6 building[2], in this building, the most important is the karaoke room as the room with the main functions, and the corridor.

Corridors that have used recommendation materials have a reliability value of 2.96, while for karaoke rooms, the reliability value is 3.12. Both are at a good level (Table 18).

Table 18. Comparison Results of Reliability Values between Corridors and Karaoke Rooms

Variable	Sub-Variable	Reliability Value Of Existing Materials	Reliability Value Of Material Recommendation
Karaoke Room	Material Resistance to Fire	2,27 - Sufficient	3,72– excellent
	Toxicity	2,42– Sufficient	3,21 – Good
	The Rapid Spread of Fire	2,79 – Sufficient	3,48– excellent
Reliability Value		2,25 – Sufficient	3,12 – Good
Corridor	Material Resistance to Fire	3,21 – Good	3,44– excellent
	Toxicity	2,86 – Good	3,15 – Good
	The Rapid Spread of Fire	3,78– excellent	4,00– excellent
Reliability Value		2,76 – Good	2,96 – Good

Acknowledgment

The study results are expected to be useful as a reference for the user and the provider of the entertainment building, especially karaoke building, to find out the circumstances and problems on the interior materials as passive fire protection in karaoke building.

REFERENCES

[1] Saaty, Thomas L., Metode AHP dan Standar Penilaian Kepentingan Variabel Sistem Proteksi Kebakaran, 2001.

[2] B. S. Nasional, Tata Cara Perencanaan Sistem Proteksi Pasif untuk Pencegahan Bahaya Kebakaran pada Bangunan Rumah dan Gedung, Jakarta: Badan Penerbit PU, 2000.

[3] N. F. P. Association, Life Safety Code, USA: NFPA 101, 2000.

[4] D. P. Umum, "Persyaratan Teknis Sistem Proteksi Kebakaran pada Bangunan Gedung dan Lingkungan," Jakarta, 2000.